T06D05 – Design: Investigation of the kinetics of a catalyzed reaction

Name……

Now we are at the end of the HL material for the topic you should all be familiar with the study of reaction kinetics.

Your task is to design an experiment that will allow you to investigate a rate-related variable of the Pink Catalyst demonstration.

Oxidation of potassium sodium tartrate by hydrogen peroxide solution to give a mixture of oxygen and carbon dioxide gases

- Reaction is catalyzed by $CoCl_2$
- As the experiment proceeds the pink color of the aqueous Co^{2+} ions changes to green Co^{3+} (intermediate), before returning to pink indicating a regeneration of the catalyst.

- **Procedure for the ORIGINAL lab**
  - Using a graduated cylinder, measure out 100 mL of 0.2 M potassium sodium tartrate solution and pour it into a 500-mL or 1-L beaker.
  - Place the beaker on a hot plate at a medium setting and slowly warm the solution to 70 °C.
  - When the temperature of the potassium sodium tartrate solution reaches 70 °C, carefully add 40 mL of 6% hydrogen peroxide. No reaction is observed.
  - Note the initial pink color of the cobalt chloride solution, and then add the solution to the 500-mL beaker and stir.
  - Observe the rate and progress of the resulting chemical reaction. *(The solution turns bright green and vigorous bubbling ensues within one minute. The mixture begins to froth and foam, then just as suddenly subsides. When the rate of bubbling diminishes, the green color disappears and the pink color of the cobalt chloride solution returns.)*

Theory:

The basic reaction appears to be:

$$5H_2O_2\,(aq) + C_4H_4O_6^{2-}(aq) \rightarrow 4CO_2 + 2OH^-(aq) + 6H_2O(l)$$

This equation may also be written in two parts:

$$3H_2O_2(aq) + C_4H_4O_6^{2-}(aq) \rightarrow 2CO_2(g) + 2H_2O(l) + 2OH^-(aq)$$

$$2HCOO^-(aq) + 2H_2O_2(aq) \rightarrow 2CO_2(g) + 2H_2O(l) + 2OH^-(aq)$$

The reaction is catalysed by pink Co^{2+} ions which are first oxidized to green Co^{3+} ions (complexed by tartrate ions) and then reduced back to Co^{2+}.

While the majority of gas evolved is CO_2, O_2 will also be produced from the decomposition of some of the H_2O_2. The gas mixture will turn limewater milky, but does not extinguish a glowing splint.

1. Defining the Problem and Selecting Variables
C P N n/a • Independent Variable
C P N n/a • Dependent Variable
C P N n/a • Research Question (using variables)
C P N n/a • Literature Values (or statement of none)
C P N n/a • Cite (MLA) sources for Lit Values
C P N n/a • Hypothesis based on Literature Values
C P N n/a • Brief explanation of the experiment
C = 2 P = 1 N = 0

2. Controlling Variables
C P N n/a • **Table 1** Control Variables (include all below)
C P N n/a • Justify the need to control / effect on results
C P N n/a • Specifically describe how each is controlled
C P N n/a • Measurement of the control
• What instrumentation is needed
• Frequency of measurements
C P N n/a • Explain which variables that can't be controlled
C P N n/a • State if Quantitative vs Qualitative Control
Is measurement or observation needed
C = 2 P = 1 N = 0

3. Developing a Method for Collecting Data
C P N n/a • Procedure is detailed, easy to repeat
C P N n/a • Cite (MLA) sources if used for procedure
C P N n/a • Materials list is complete
C P N n/a • Units, precision, size, formula of materials
C P N n/a • Sufficient range of independent variable
C P N n/a • Appropriate # of trials selected
C P N n/a • Picture (or drawing) of apparatus
C P N n/a • Collection of Data (explanation or table)
C = 2 P = 1 N = 0